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(54) Device for measuring the permeability of rock fragments

(57) The present invention relates to a device used for the direct measurement of the permeability of rock fragments coming directly from the drilling of an oil well and commonly called cuttings, consisting of a hollow cylindrical body (c) that presents an inlet hole for the fluid (i), a thread for closing it (h) and a hydraulic seal (g) in which is placed the sample holder disk (d) which rests on the seal (g) and is overlapped by a porous sintered steel septum (e) on which a closing plug (f) is situated with an outlet hole for the fluid (i') and the same is also provided with a thread (h') to enable it to close on the body (c).

The device can be used to obtain, directly on site, the measurement of permeability along the whole length of an oil well.

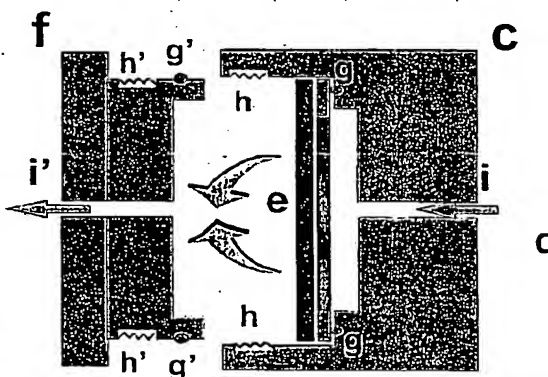


Fig. 2

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Description

The present invention relates to a device used for the direct measurement of the permeability of rock fragments coming directly from the drilling of an oil well and commonly called cuttings, consisting of a hollow cylindrical body (c) that presents an inlet hole for the fluid (i), a thread for closing it (h) and a hydraulic seal (g) in which is placed the sample holder disk (d) which rests on the seal (g) and is overlapped by a porous sintered steel septum (e) on which a closing plug (f) is situated with an outlet hole for the fluid (i') and the same is also provided with a thread (h') to enable it to close on the body (c).

The device can be used to obtain, directly on site, the measurement of permeability along the whole length of an oil well.

The sample holder disk (d) is shown in figure 1 and constitutes another part of this invention.

Determination of the permeability of rocks involved in drilling and oil production, constitutes an essential part of the activity known as "Formation Evaluation" carried out by all oil companies.

Amongst those measurements carried out in the laboratory on samples of rock taken from cores for petrophysical characterisation, the determination of permeability is fundamental; in fact this carrying property defines the capacity of a material (rock for example) to allow one or more fluids (e.g. water, gas or oil) to pass through it.

At present, direct measurement of permeability is only possible on samples of rock taken from a test core; the main limits of this method such as times (considerable, because the core must be obtained and samples sent to a laboratory for analysis) and costs (connected, above all, with the withdrawal of the test core itself and which can be incurred only for samples coming from the so called "pay zones" and certainly not for the entire length of the oil well) mean that permeability is known only for the sections of a well that have been cored and only a long time after the drilling operations.

In order to find solutions to these considerable limitations and to establish the permeability of rock formations, it has been developed several semi-empirical correlations between permeability and other petrophysical properties such as porosity, clay content, speed of sound waves, electrical measurements etc. determinable by probes inserted into the oil well (logs); this indirect method of determining permeability, even if requires difficult calibration operations depending on the lithology in question, it is, at present, the only method available in those parts of the well from which cores have not been taken but, having at times no clear physical meaning, it is in any case far from being as reliable as direct measurement.

The Applicant has now developed a device that, by direct determination of permeability on cuttings, provides fundamental information on the nature of the rock strata crossed during drilling, so that fast actions can be

taken if necessary.

This invention therefore relates to a device used for the direct measurement of the permeability of rock fragments coming directly from the drilling of an oil well and commonly called cuttings, consisting of a hollow cylindrical body (c) that presents an inlet hole for the fluid (i), a thread for closing it (h) and a hydraulic seal (g) in which is placed the sample holder disk (d) which rests on the seal (g) and is overlapped by a porous sintered steel septum (e) on which a closing plug (f) is situated with an outlet hole for the fluid (i') and the same is also provided with a thread (h') to enable it to close on the body (c).

The purpose of this invention is to obtain, directly on site, the measurement of permeability along the whole length of an oil well.

The sample holder disk (d) used by the Applicant to measure permeability through rock fragments, is shown in figure 1 and also constitutes a further part of this invention.

It consists of a resin (b), initially placed in its liquid state in a circular mould, in which the cuttings (a) are encapsulated; after the resin has hardened, the disk is ground so that its faces are flat and parallel and so that the two surfaces of each encapsulated cutting are exposed on each side of the disk.

Particular care must be taken in choosing the resin (b), which must have the following properties:

- non-aggressive even for highly permeable cuttings;
- non-toxic for use on site;
- easy to prepare and with a high degree of homogeneity;
- hardening with fast setting time at atmospheric pressure and without the production of excessive heat which might modify the properties of the cuttings;
- high rigidity after setting;
- easy to cut and to grind;
- optically opaque to permit the determination of the exposed surfaces of rocks.

Particularly, the resin (b) is chosen among epoxy, polyurethane or acrylic resins.

Figure 8 shows a photograph of a sample holder disk (d) realized by an electronic microscope (SEM) in which it can be seen that the resin (b) does not penetrate inside the porous matrix of the cutting (a) even with highly permeable samples (the photograph in question is of a sandstone of 530 millidarcy (mD)).

Figure 2 shows a cross section of the device object of this invention: it consists of a hollow cylindrical body (c) that presents an inlet hole for the fluid (i), a thread for closing it (h) and a hydraulic seal (g) in which is placed the sample holder disk (d) which rests on the seal (g) and is overlapped by a porous sintered steel septum (e) on which a closing plug (f) is situated with an outlet hole for the fluid (i') and the same is also provided with a thread (h') to enable it to close on the body (c).

In particular, the porous septum (e) is used to prevent the sample holder disk (d) from bending and breaking.

Only for the purpose of illustrating the invention and without being in any way limitative of the invention itself, figure 3 shows a diagram of the hydraulic circuit used for measurement: it consists of a pump (α) which ensures a pressure difference between the two faces of the disk (d), measured by a manometer (β), while the flow rate of the fluid employed for the measurement is provided by a flowmeter (γ).

Experiments are carried out as follows: the sample holder disk (d) is prepared as described above and, after grounding, the surface area of the exposed cuttings on the two faces of the disk itself is calculated using transparent millimetre graph paper or a video camera and image recognition software that will calculate the area for the flow semi-automatically.

The disk (d) is then inserted in the measuring device, object of this invention, allowing the passage of the fluid to be tested through the cuttings encapsulated in it; creating pressure differences between the two faces of the disk by the pump (α), the corresponding flow rates of the fluid are measured using the flowmeter (γ) and such values, inserted in the Darcy equation, permit to determine the hydraulic permeability (stationary method).

It is also possible to perform a non stationary flow test in the same way by employing the pump (α) to create a pressure difference between the two faces of the disk (d) and by measuring the time required to reach the equilibrium.

The device, object of this invention, therefore uses said resin disks, allowing direct measurement of permeability on cuttings as it is done on samples taken from a test core.

The Applicant, without any limitation to the content of this invention, has constructed devices with the body both in steel and plexiglas with which a series of measurements were made to demonstrate the feasibility of the method.

Preliminary tests were carried out with disks containing sandstone and clay cuttings which were then inserted in the measurement device and fluxed with gaseous nitrogen; the results are given in figures 4, 5 and 6 for Doddington sandstone, Sprintwell sandstone and clay respectively, the curves of which on the graphs show the time (in hours, minutes and seconds on the abscissa) needed to dissipate a pressure difference of 3.5 bar (on the ordinate) applied between the two faces of each disk of cuttings.

Figure 7, on the other hand, shows a pressure against (on the ordinate expressed in bar) flow rate graph (on the abscissa expressed in cc/min.) for stationary flow through the disk containing clay cuttings.

The next step was to check whether the permeability values, obtained using the device object of this invention, were consistent with those measured using the traditional method on a test core.

For this, three ceramic samples of known and certified permeability (1 mD, 5 mD and 50 mD) were employed on which permeability was measured on test cores using the traditional method; at the same time, the samples were crushed to obtain "synthetic" cuttings on which permeability was measured using the measuring device object of this invention obtaining results that fell within the limits of experimental error.

Further tests were carried out on sandstone test cores coming from the rock reservoir of an oil well; permeability was measured using the stationary method on samples taken from the cores and characterised by very wide ranging degrees of permeability (from tenths of an mD to greater than 500 mD).

Afterwards, "synthetic" cuttings were obtained by crushing and permeability was measured using the device object of this invention.

The permeability measurements obtained on these cuttings were substantially the same as those obtained on the core (Table 1).

Finally, then, the method described here adds to and improves on existing known methods in a completely unexpected way and can be used as an industrial instrument for a campaign of on site measurements.

The costs of measuring permeability are quite low because of the availability of cuttings during drilling and also because the method can form part of a package of on site measurements on cuttings: acoustic, mechanical and petrophysical measurements.

Tab. 1

CORE (mD)	CUTTINGS (mD)
520	540
190	190
64	62
20	25
103	64
270	235
28	9.3
11	6.2

Claims

1. Device used for the direct measurement of the permeability of rock fragments coming directly from the drilling of an oil well and commonly called cuttings, consisting of a hollow cylindrical body (c) that presents an inlet hole for the fluid (i), a thread for closing it (h) and a hydraulic seal (g) in which is placed the sample holder disk (d) which rests on

the seal (g) and is overlapped by a porous sintered steel septum (e) on which a closing plug (f) is situated with an outlet hole for the fluid (i') and the same is also provided with a thread (h') to enable it to close on the body (c).

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2. Device, according to claim 1, characterised by the fact that the material of which the body (c) and the plug (f) is made is steel or plexiglas.

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3. Device, according to claim 1, characterised by the fact that the seals used are O-rings.

4. Sample holder disk consisting of a resin (b) in which cuttings (a) are encapsulated, which presents flat, parallel faces with the two surfaces of each encapsulated cutting exposed on each side.

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5. Sample holder disk, according to claim 4, characterised by the fact that the resin (b) is chosen among epoxy, polyurethane or acrylic resins.

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6. Direct measurement of the permeability of rock fragments coming directly from the drilling of an oil well employing the device, according to claim 1, a pump (α) that provides a pressure difference, a manometer (β) suitable for measuring the said pressure difference on the two faces of the disk (d) and a flowmeter (γ) that measures the flow rate of the fluid used.

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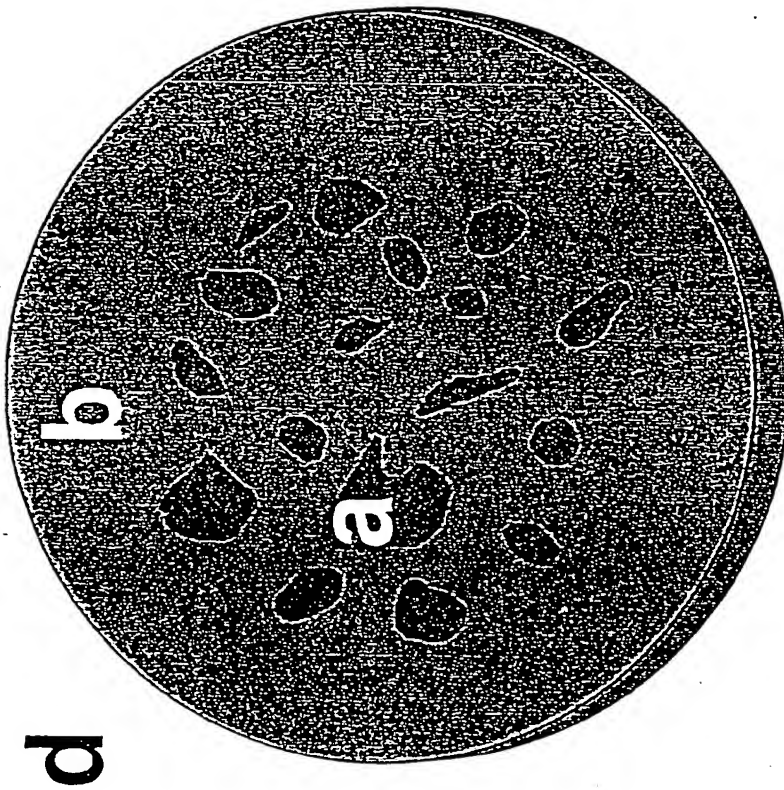
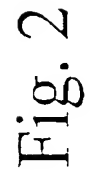


Fig. 1

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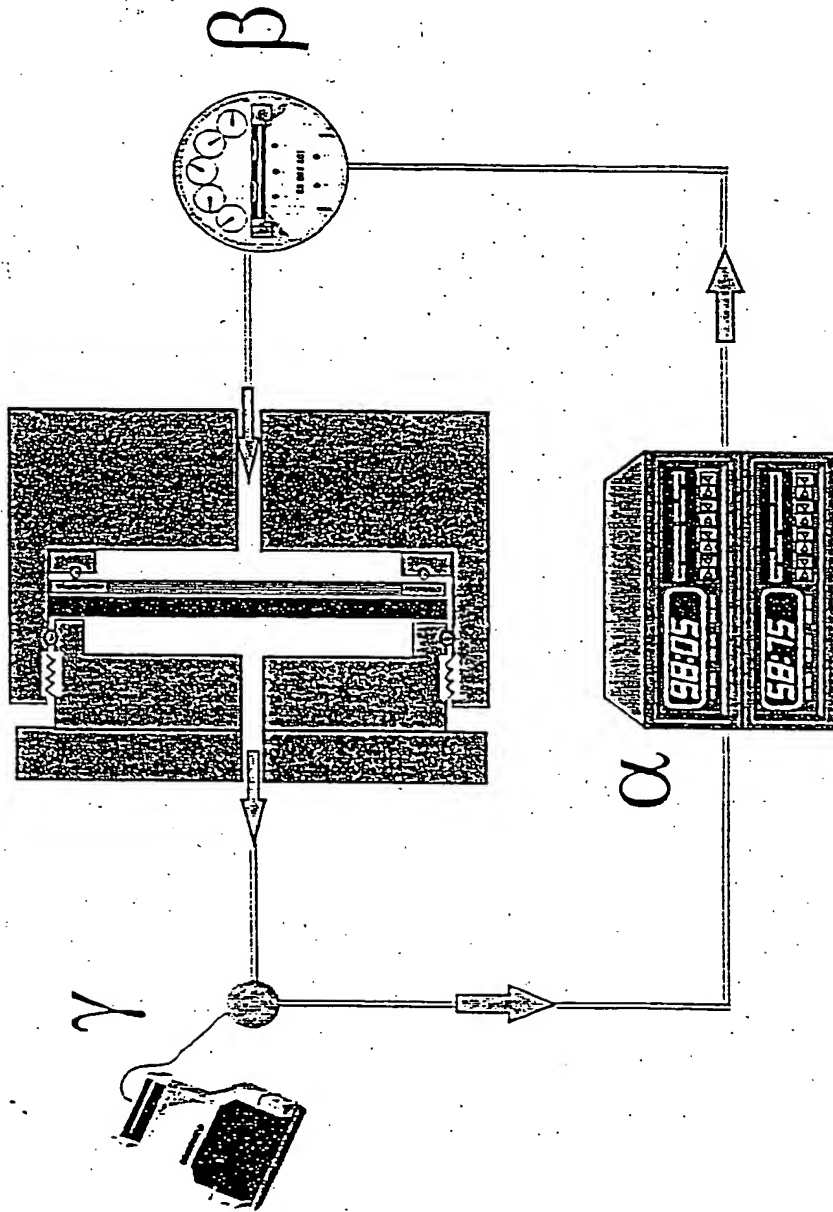


Fig. 3

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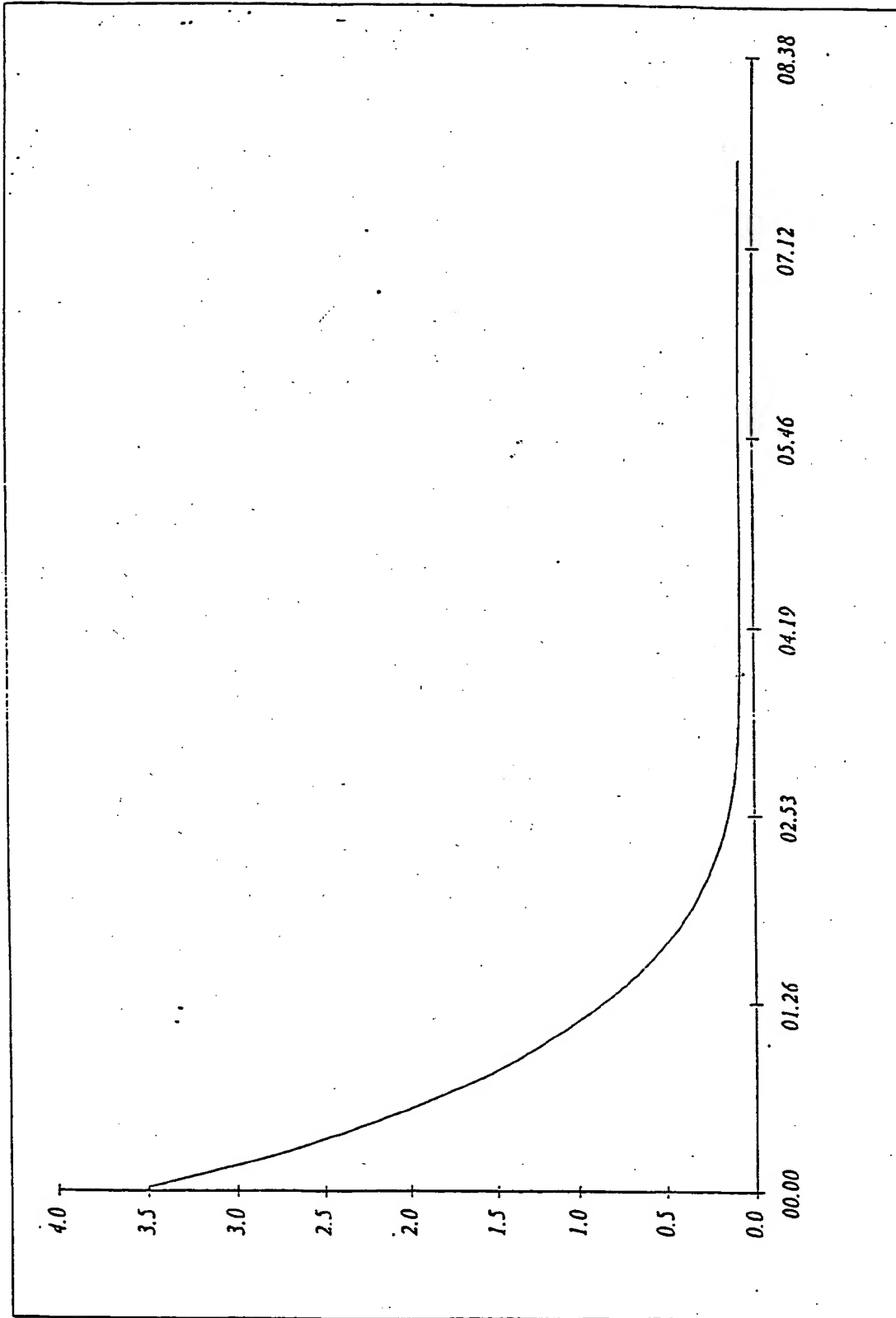


Fig. 4

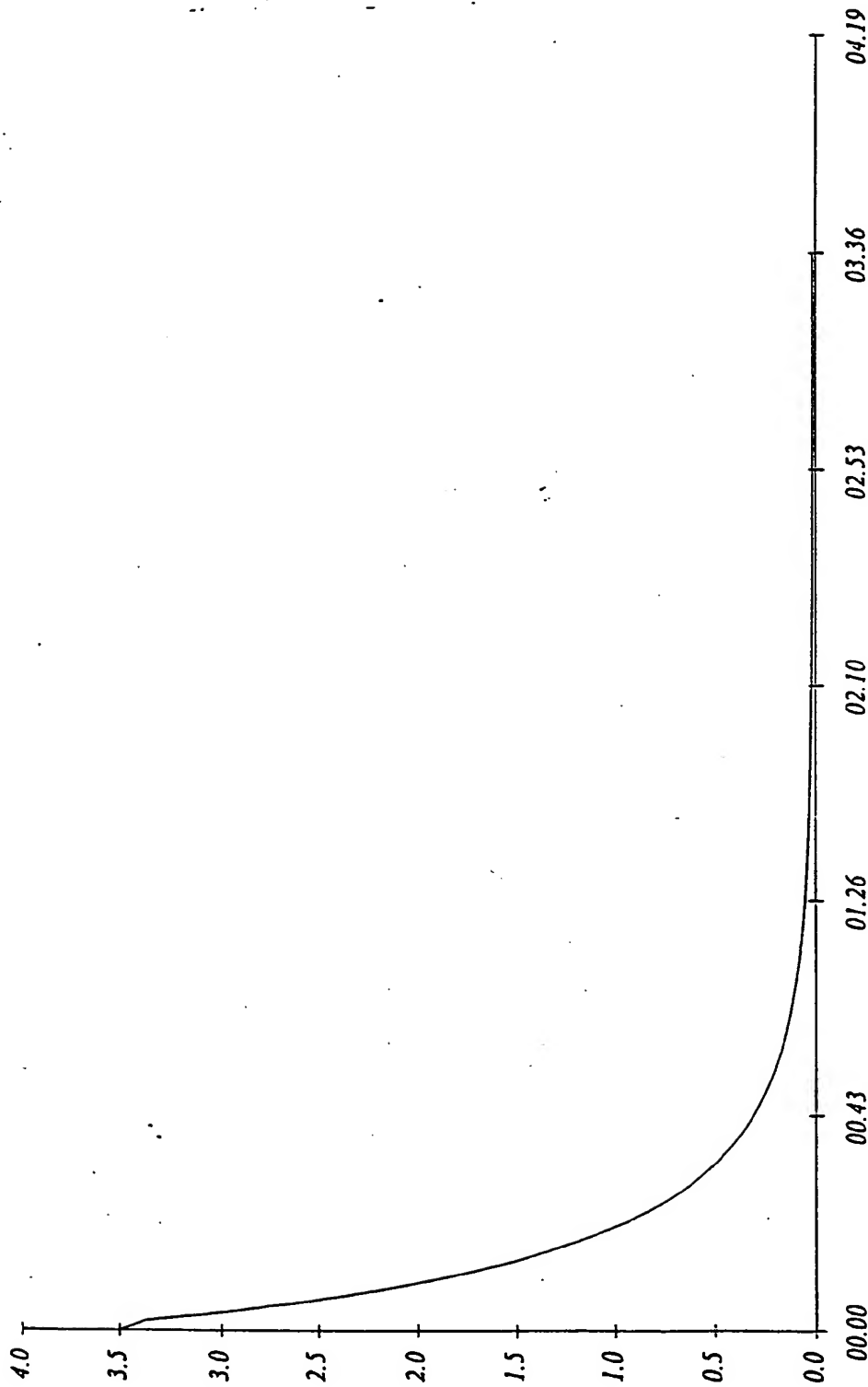


Fig. 5

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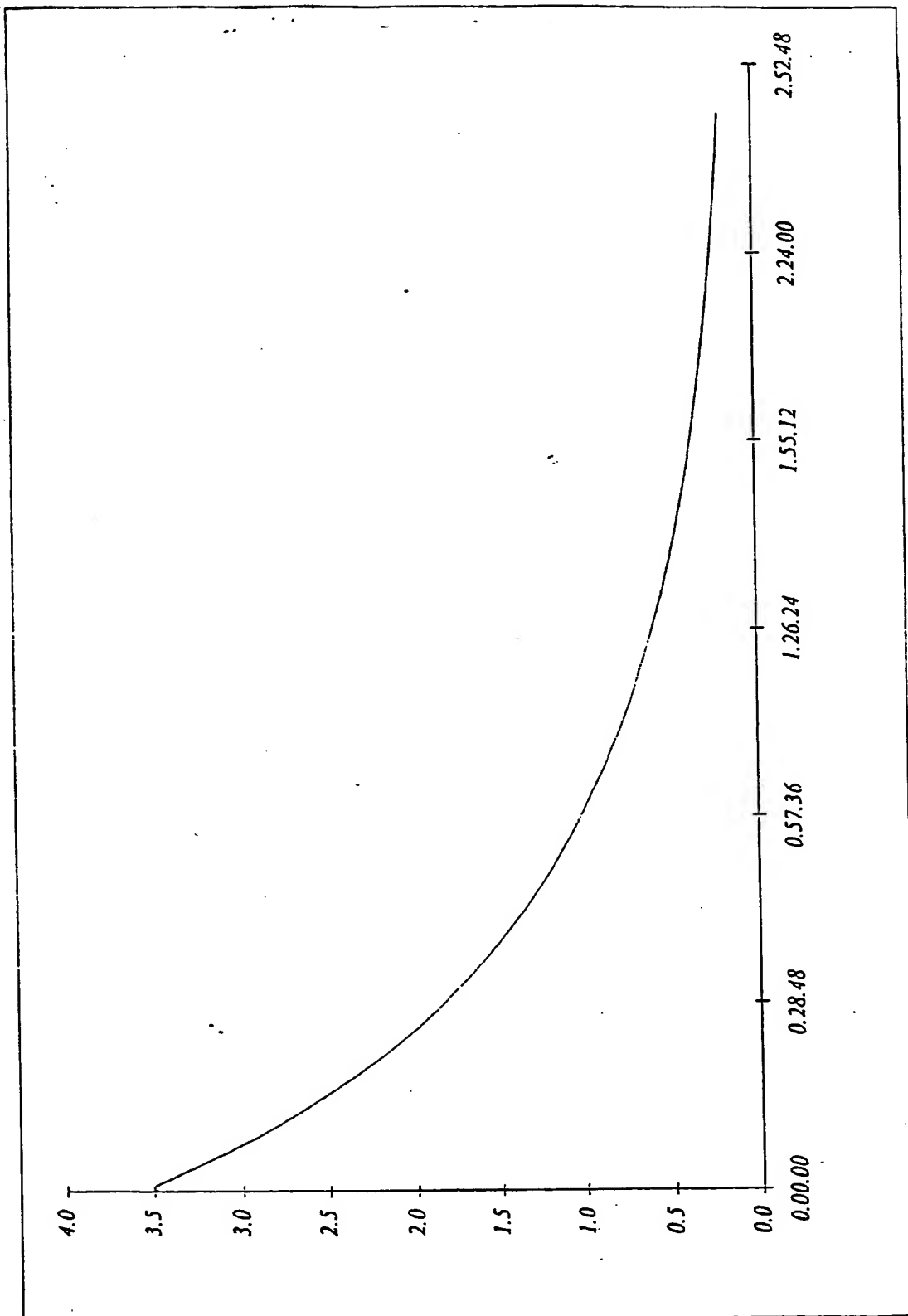


Fig. 6

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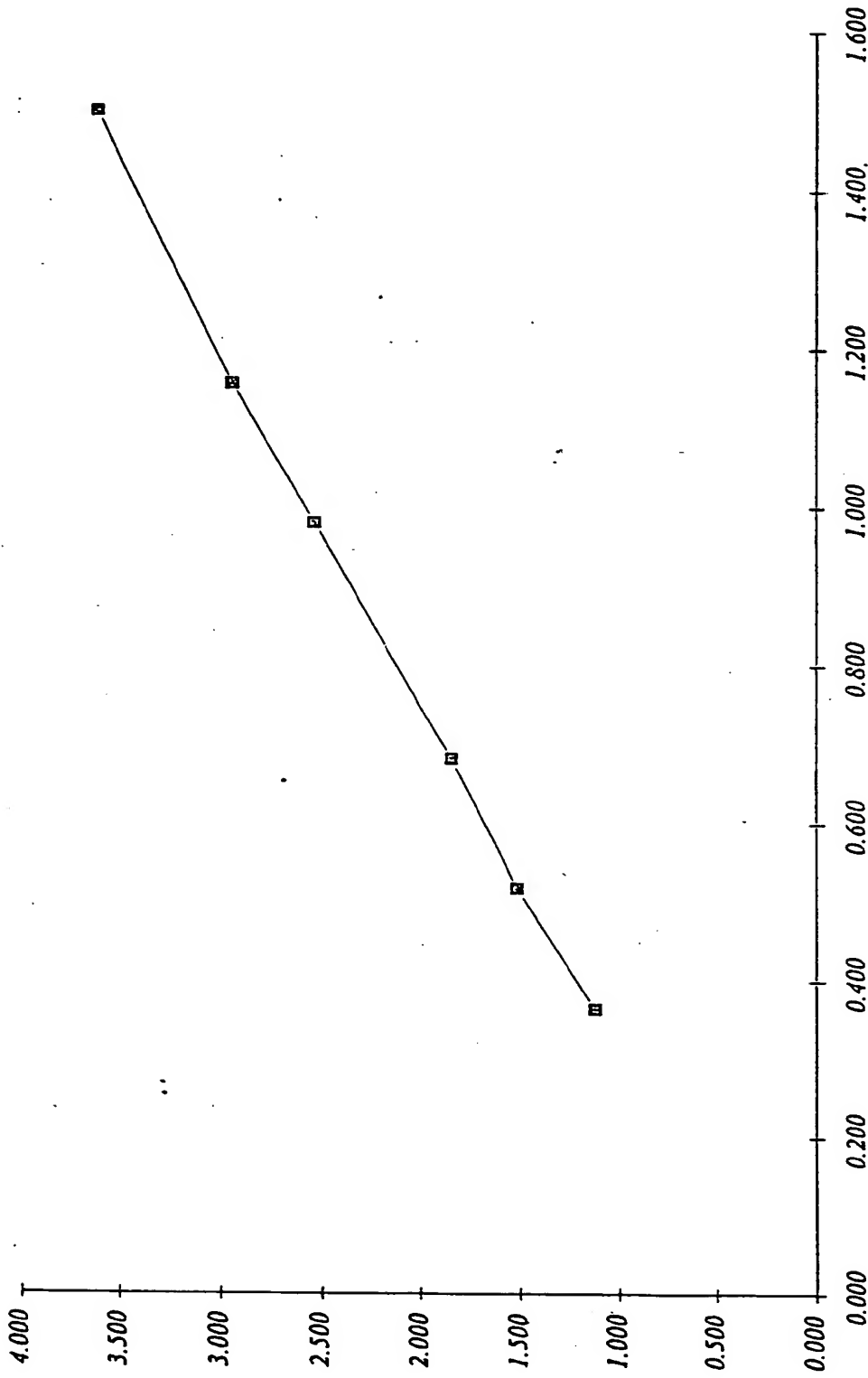


Fig. 7

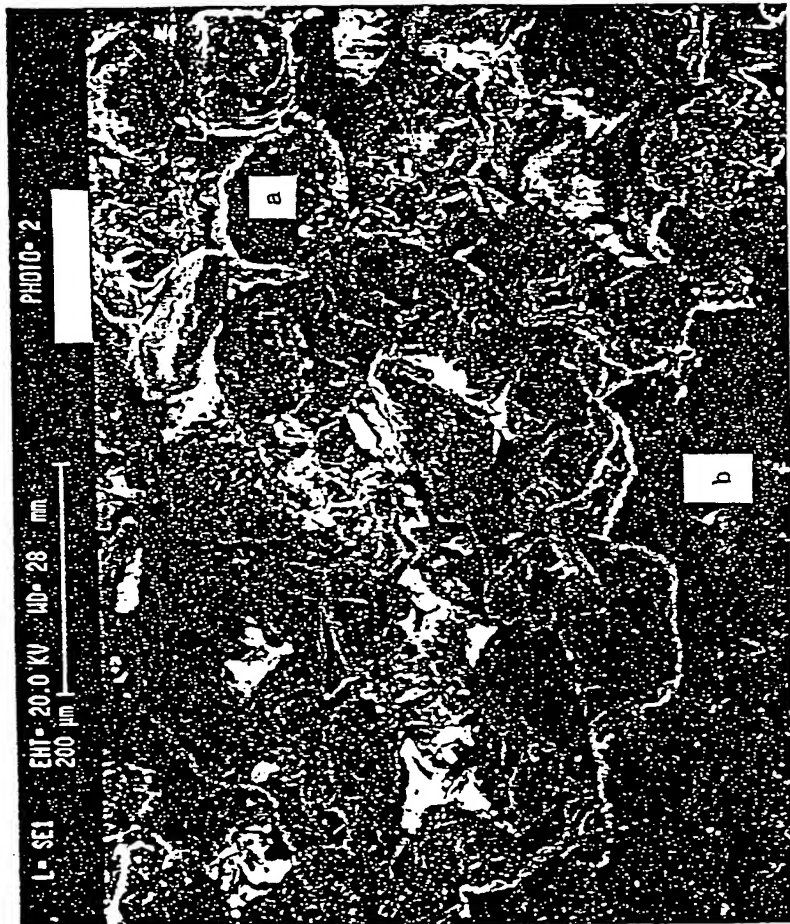


Fig. 8

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EUROPEAN SEARCH REPORT

Application Number
EP 97 10 0287

DOCUMENTS CONSIDERED TO BE RELEVANT

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
Y	US 4 555 934 A (FREEMAN DAVID L ET AL) 3 December 1985 * the whole document *	1-3,6	G01N15/08 G01N33/24
X	* column 6, line 10 - line 35 * ---	4,5	
Y	US 5 285 692 A (STEIGER RONALD P ET AL) 15 February 1994 * the whole document *	1-3,6	
Y	EP 0 465 168 A (AMOCO CORP) 8 January 1992 * page 4, line 51 - page 5, line 17 *	1-3,6	
A	US 2 662 401 A (FLORENT H. BAILLY) 15 December 1953 * the whole document * -----	1-6	
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
			G01N
The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
MUNICH		22 April 1997	Mueller, T
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